

Biology is the study of living species. The historic origin of biology is descriptive in nature, a classification and description of the various biological species. Modern biology is far different and seeks to understand living phenomena on a molecular basis. The incredible amount of information available and the databases of this information are staggering, the most obvious example being the nucleotide sequence of the human genome. In essence, biology has moved from a qualitative to a quantitative science. Inevitably, this requires a theoretical framework and associated mathematics. Physical chemistry provides this framework for molecular structure and chemical reactions, the components of all biological systems that ultimately must be understood.

Traditionally, physical chemistry has been a major training component for chemists, but not for biologists. This has been attributed to the relatively sophisticated mathematical underpinnings of rigorous physical chemistry. However, the concepts of physical chemistry can be understood and applied to biology with a minimum of mathematics.

This volume attempts to present physical chemistry in conceptual terms using mathematics only at an upper level of elementary calculus, a level required for all science students. Nevertheless, the approach is quantitative in nature, with explicit calculations and numerical problems. Examples from biology are used to illustrate the principles, and problems are appended at the end of each chapter. This book is intended to serve as a one-semester introduction to physical chemistry for undergraduate biology majors and as a refresher course for first-year graduate students. This book combines two volumes published earlier, *Thermodynamics and Kinetics for the Biological Sciences* and *Spectroscopy for the Biological Sciences*. These two books have been integrated with some additions and modification. The most notable addition is a chapter on the hydrodynamics of macromolecules. Hydrodynamics is the basis of several important laboratory techniques used in molecular biology, and understanding the underlying concepts will permit better use of the methods and development of new methods.

We begin with a discussion of thermodynamics, a subject that provides a convenient framework for all equilibrium phenomena. This is followed by chemical kinetics, the quantitative description of the time dependence of chemical reactions. For both subjects, multiple applications to biology are presented. The concepts associated with spectroscopy and structure determination are then considered. These topics deal with the molecular nature of matter and the techniques used to characterize molecules and their interactions. The concluding section of the book includes the important subjects of ligand binding to macromolecules, hydrodynamics, and mass

spectrometry. The coverage of this book represents the minimal knowledge that every biologist should have to understand biological phenomenon in molecular terms (in my opinion!).

I am indebted to my colleagues at Duke for their encouragement and assistance. In particular, Professors Jane and David Richardson, Lorena Beese, Leonard Spicer, Terrance Oas, Michael Fitzgerald, and Harvey Sage who have provided vital expertise. A special thanks also goes to Darla Henderson who as a Wiley editor has provided both encouragement and professional assistance in the preparation of this volume. As always, my wife Judy has provided her much appreciated (and needed) support.

GORDON G. HAMMES
Duke University
Durham, NC, USA

Preface to Second Edition

The impetus for preparing the second edition was twofold. First, the material in the first edition was brought up to date. Although the argument can be made that the principles of physical chemistry are timeless, new applications continually appear. We have tried to ensure that interested students will have access to the most recent developments in the areas covered in this book. Second, with the addition of a co-author, we have significantly expanded and upgraded some of the theoretical aspects of this book. The flavor of the first edition has been retained: students in the biological sciences can still obtain a working knowledge of physical chemistry without utilizing advanced calculus. However, the landscape has changed. Calculus, and even advanced calculus, is now routinely taught in high school so that many more college students have an understanding of advanced calculus. Also research in the biological sciences now includes many more applications of theory relative to ten years ago.

More specifically, five new chapters have been added. The first deals with some of the advanced aspects of thermodynamics and makes use of multivariable calculus. Two of the chapters discuss quantum mechanics in much more detail and at a higher level than the first edition. The additions include a discussion of hydrogen tunneling, as well as a chapter on atomic and molecular electronic structure, with brief treatments of Hartree-Fock and density functional theory. The last two new chapters discuss statistical mechanics. One chapter deals with the fundamentals of the subject, and the other discusses computer simulations, with an extensive treatment of molecular dynamics. Finally, an appendix has been added to introduce the fundamentals of electrochemistry.

As a result of these changes, the second edition contains more material than can be covered in a one semester course. However, the instructor can pick and choose the material to be included for such a course. In fact, this text is suitable for a traditional two semester physical chemistry course. Although a few traditional subjects are not covered, there is more than enough material for two semesters. We have intentionally not designed this text to be encyclopedic in nature to make it more accessible to students for self-study.

We are grateful to a number of people for their assistance in reviewing specific aspects of the book. These people include Professor Nicholas Winograd (Pennsylvania State University), Professor Terrance Oas (Duke University), and Professor Leonard Spicer (Duke University). We again want to thank Professors Jane and David Richardson for the marvelous color plates which have been retained from the first edition. Special thanks are due to Dr. Joshua Layfield, who prepared most of the figures for the new material in the second edition and provided valuable

insights. We also want to acknowledge the support of our spouses, Judy and Peter, who have provided much needed patience and encouragement in this father-daughter endeavor.

GORDON G. HAMMES
Duke University
Durham, NC, USA

SHARON HAMMES-SCHIFFER
University of Illinois
Champaign, IL, USA